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Creep Tests on Extrutech and Prime-B for NOVA

Hans Jostlein February 13, 2006

Abstract

We present updated results on long term creep tests for the Extrutech material.
We also show recent results on the elastic modulus and early creep behavior of the Prime-B material. The modulus is 360 ksi. Prime B creeps significantly faster than Extrutech. Prime B at a given stress creeps as much as Extrutech at twice the stress.

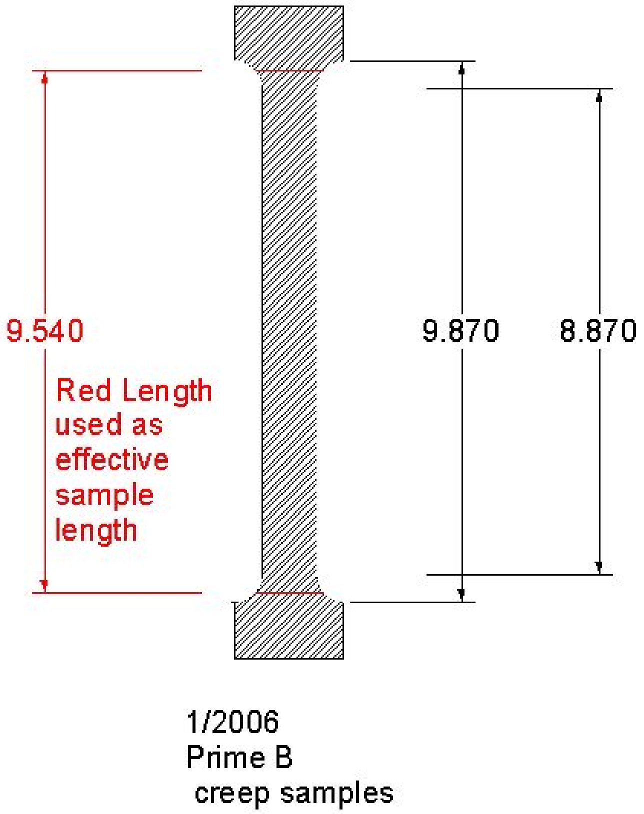
Notice: This is recent work and needs to be reviewed.

Introduction

NOVA uses PVC as a structural material.
Creep is an important contributor to peeling stresses in adhesives used to hold the structure together.
We have measured creep in a commercial PVC used by Extrutech to make wall panels.
We also have now measured creep in a material called Prime-B, which is being considered due to its high reflectivity.

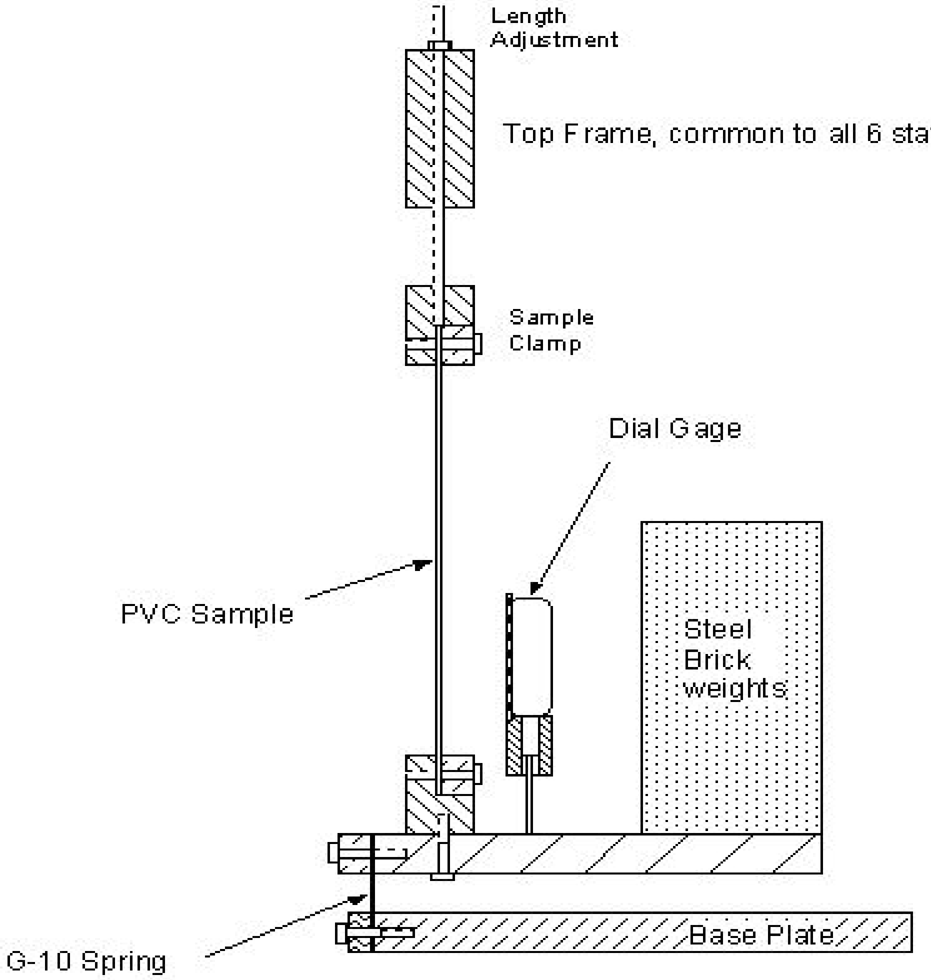
Method

We built a total of 24 dedicated test stations.
The PVC sample shape is shown here:



It similar to an ASME dogbone sample in that it has widened ends to reduce strain and stress in the clamping areas. The samples are quite long compared to standard ASME samples in order to increase the useful length of the sample, while minimizing the effects of the clamping area.

The creep tester uses weights to apply constant force and stress during the full test duration. Lever arms are used to avoid the need for inconveniently large masses. Each station has dedicated a dial gauge to track strain.



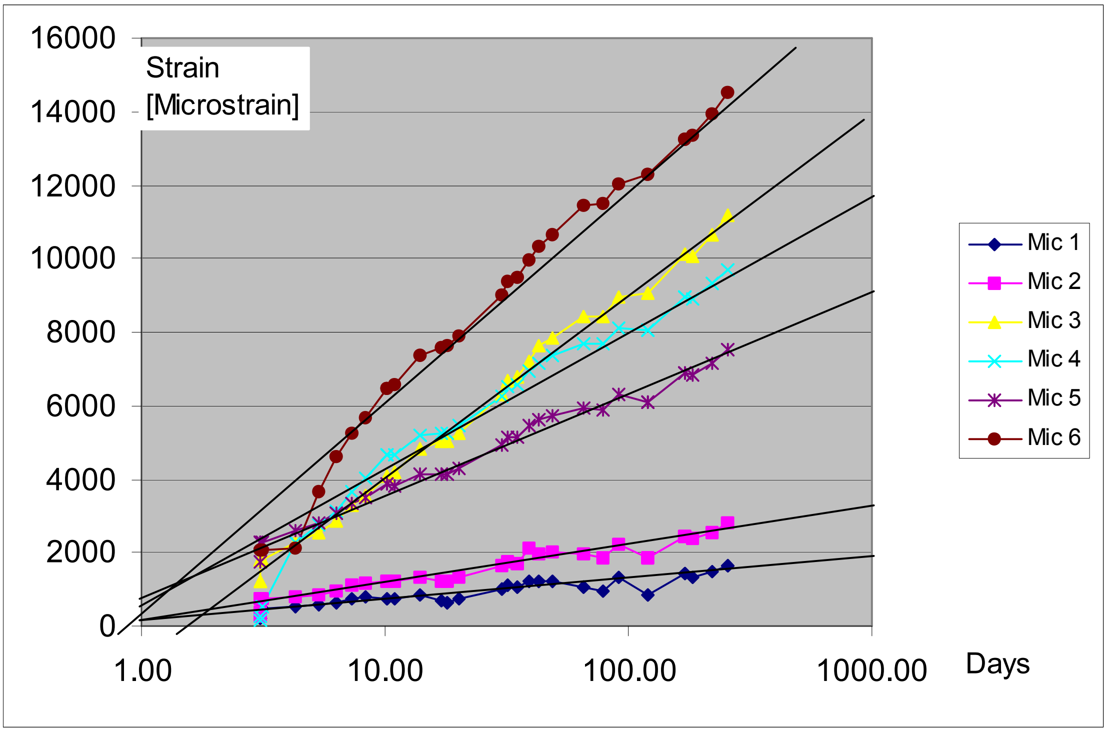
PVC Creep Tester

Extrutech Creep Data

This test uses 6 samples , subjected to this list of stresses [psi]:

633	1132	2632	2602	1964	2908

The observed creep strain is shown next:



Prime B Elastic Modulus Data

During the setup of 18 Prime-B samples, and before stressing them significantly, we loaded each strip quickly with 4 different weights to measure their elastic elongation and to derive a modulus. The stresses were between 106 and 677 psi.
The resulting moduli are listed below. They were all consistent and can be averaged to 361ksi +- 32 ksi. The “error” is the standard deviation of all data points. The expected error based on the scatter of results would be 32 ksi / sqrt(18 * 4) = 4 ksi

	Stress	Strain [microstrain]		Strip Number								
Modulus @3.5	106	**340**	362	288	353	280	375	349	367	312	334
Modulus @6.9	207	**373**	399	346	356	321	354	376	405	365	347
Modulus @13.9	415	**372**	401	348	358	328	362	365	398	359	348
Modulus @22.6	677	**358**	381	335	344	321	356	353	377	348	333

293	312	309	369	453	342	343	333	341
352	365	362	432	405	377	362	395	388
341	360	371	423	399	387	372	388	390
330	348	357	416	384	369	347	363	377

Average modulus [ksi]	**361**	386	329	353	312	362	361	387	346	341
Stdev Modulus	**32**	18	28	6	22	9	12	18	24	8

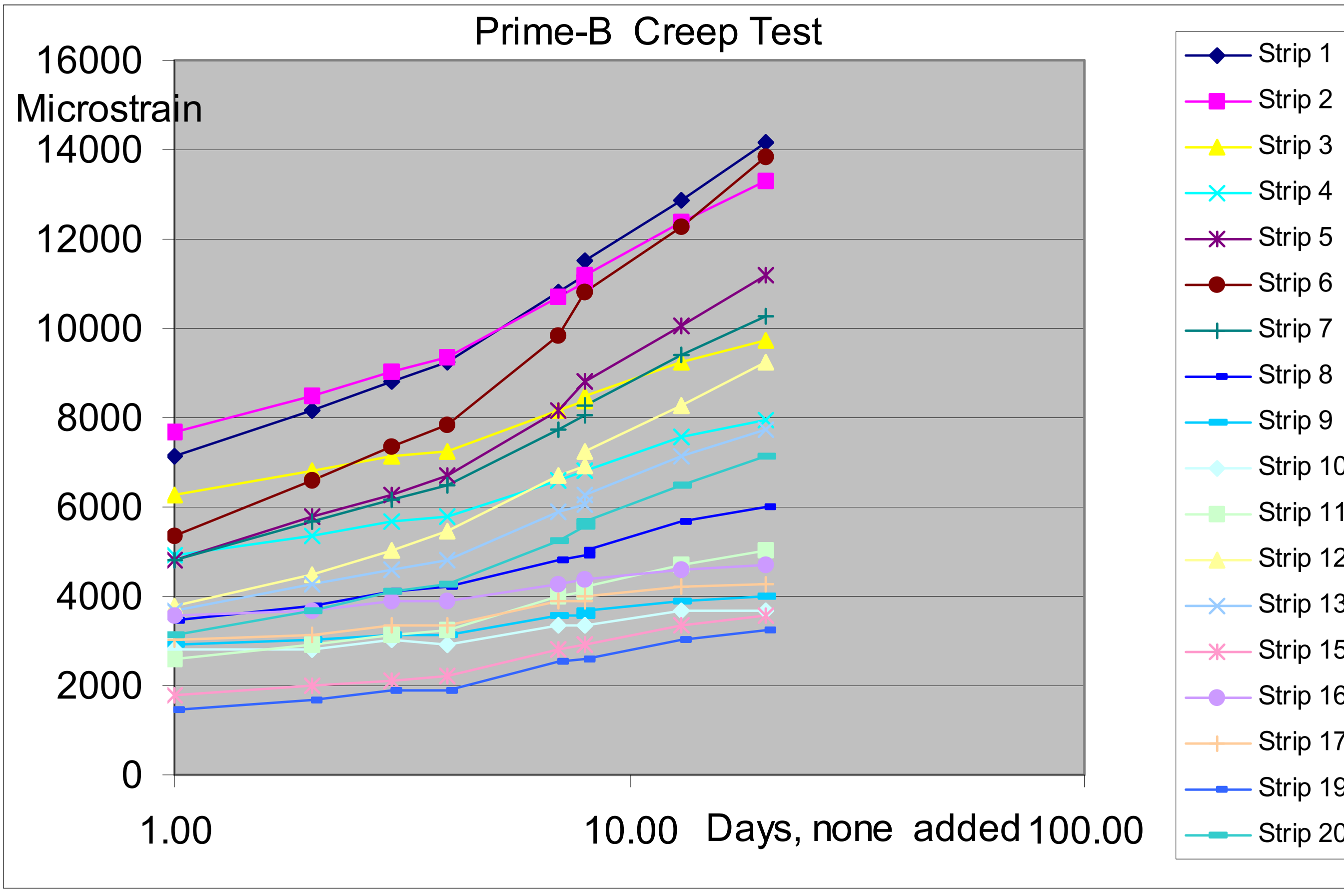
329	346	350	410	410	369	356	370	374
26	24	28	28	30	19	13	28	23

Prime B Creep Data

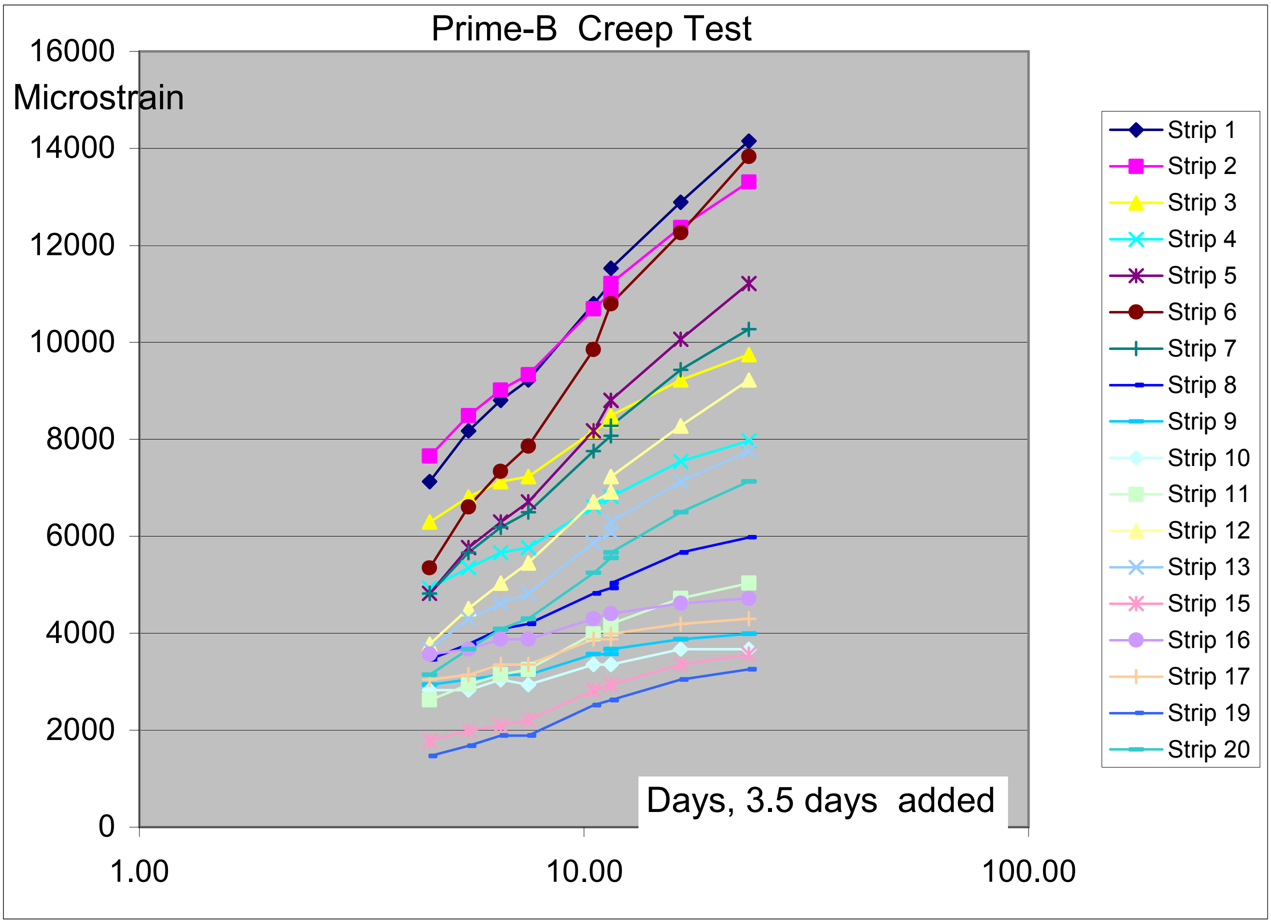
We loaded 18 Prime-B samples for the creep test with the following stresses:

Stress	2100	1900	1297	1299	1882	2101
	1814	1097	496	497	1098	1803
	1492	898	698	698	899	1504

Creeps were only taken for about 2 weeks so far.
The results are shown next:



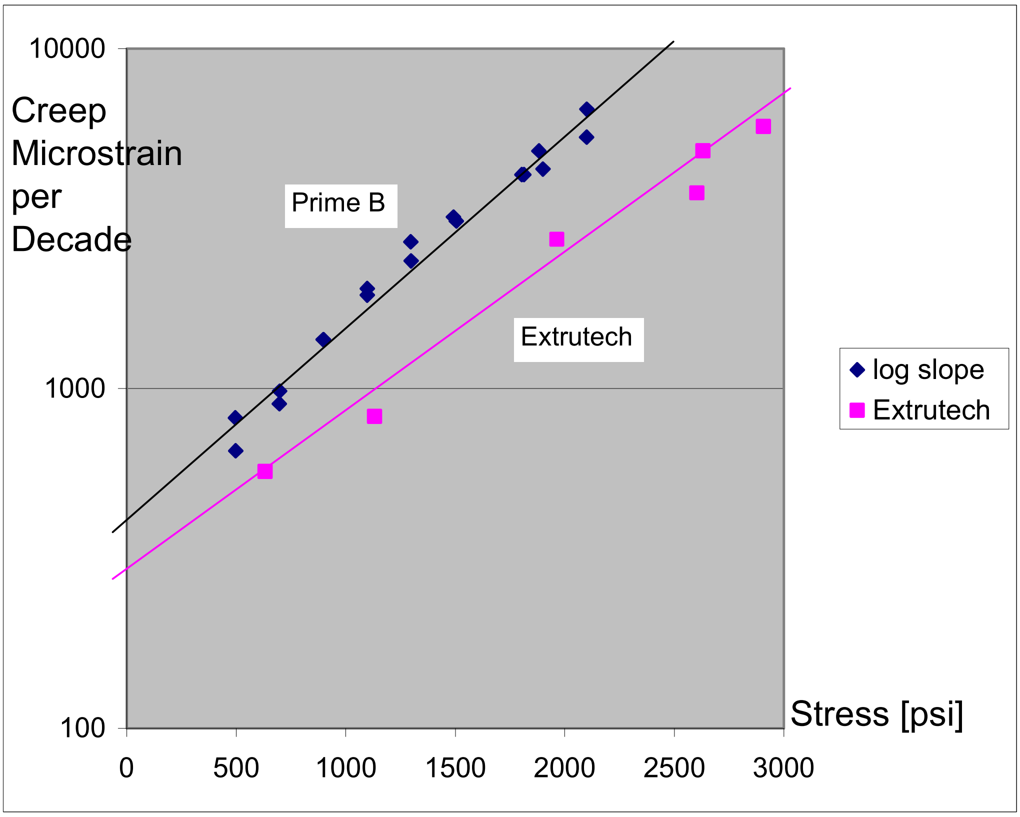
The curves start out flat and then steepen at about the 4 day mark.
This is a reflection of the fact that a log scale gets into trouble at very short end early times, and cannot represent reality there.
Empirically, without any theoretical foundation, one observes that one can straighten out all curves by adding 3.5 days to the time scale:



Creep Rate Calculation and Comparison

We can now extract the creep rate for each sample, and plot it against stress.
The creep rate is expressed in Microstrain (dl/l = 10^-6) units per decade in time.
This function is a straight line on the creep data plot.

The following graph shows the creep rate for both the Extrutech and the Prime B materials:



Assuming the analysis is correct, one can see that the Prime-B material creeps at a significantly faster rate than the Extrutech material.
This can be expressed by stating that the creep rate per decade is about twice as fast. For a 20 year lifetime, and a base time of 4.5 days, the experiment covers log (20*365/4)=3.26decades, which would be approximately a 90 times higher creep strain at the same stress.
One can also observe that the Prime B creep matches that of an Extrutech sample subjected to twice the stress.

Independent verification is needed.